



# Orbit Design

**Jim Barnds**  
**Orbit/Navigation Team Lead**  
**NRL**  
**202-767-4001**  
**[jbarnds@space.nrl.navy.mil](mailto:jbarnds@space.nrl.navy.mil)**



# Requirements



- **Minimize Eclipsing Over Mission**
- **Minimize Propellant Consumption**
- **Maintain Visibility Over BP Once on Mission Orbit (5° Minimum Elevation)**
- **Dispose of Observatory in Approved Disposal Orbit (Geo+335/geo-500km)**
- **Dispose of AKM in Approved Disposal Orbit (Geo+320/geo-500km)**
- **Perform Maneuvers to Achieve and Maintain Mission Orbit**
- **Perform AKM Firing Within View of BP/DSN Site**
- **Booster Firings Must Occur Outside African Exclusion Zone**



# Baseline Approach (1 of 3)



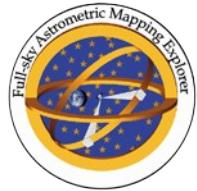
- **Orbit Transfer Plan Places Observatory in Orbit With LAN at  $105^\circ$  W and Minimizes LAN Drift**
- **Place RAN of Mission Orbit at  $191^\circ \pm 10^\circ$** 
  - **Two Annual Earth Eclipse Seasons Lasting 20-21 Days (72 Min Max)**
  - **Lunar Eclipses (Up to 4 Penumbral Eclipses/yr, 45 Min Max)**
- **Place AOP of Mission Orbit Near  $149^\circ$  (Conjunction Avoidance)**
- **No Planned Adjustment to Inclination (<30.4° Expected)**
- **Jettison AKM Into SubSync Disposal Orbit (GEO - 500 km)**
- **Plan Contingency Orbit Transfers to Accommodate Impulse/pointing Errors During Maneuvers and Missed Maneuvers**
- **Plan Potential Orbit Trim Maneuvers (~1.25 Years) to Minimize LAN Drift**
- **Transfer Observatory to SuperSync Disposal Orbit (GEO + 335 km) at EOL**



# Baseline Approach (2 of 3)



- **Stage-I + Initial Stage-II Firing Establish 185x185 km Parking Orbit**
- **Extended Wait on Parking Orbit For Stage-II Re-Ignition and Stage-III Firing**
  - Places GTO Insertion Maneuver Over the Indian Ocean
  - Forces Favorable Sun Angle (135°) for AKM Firing
- **Dwell of 2.5 Revs/25:53 on GTO (185x35287 km)**
  - Trim GTO Apogee After 1 Rev/10:21 to Remove  $\pm 540$  km Insertion Error
  - Allow Ground Track Drift to Desired LAN
  - Collect Radiometric Data for Orbit Determination
- **AKM Firing to SubSync (35287x35287 km) AOS@BP: AKMF - 4:22**
  - Trim Orbit to Approved GEO-500 km Altitude and Jettison
  - Backup AKM Maneuver Uses 1 Rev Delay aos@dsn/madrid: AKMF - 3:35



# Baseline Approach (3 of 3)



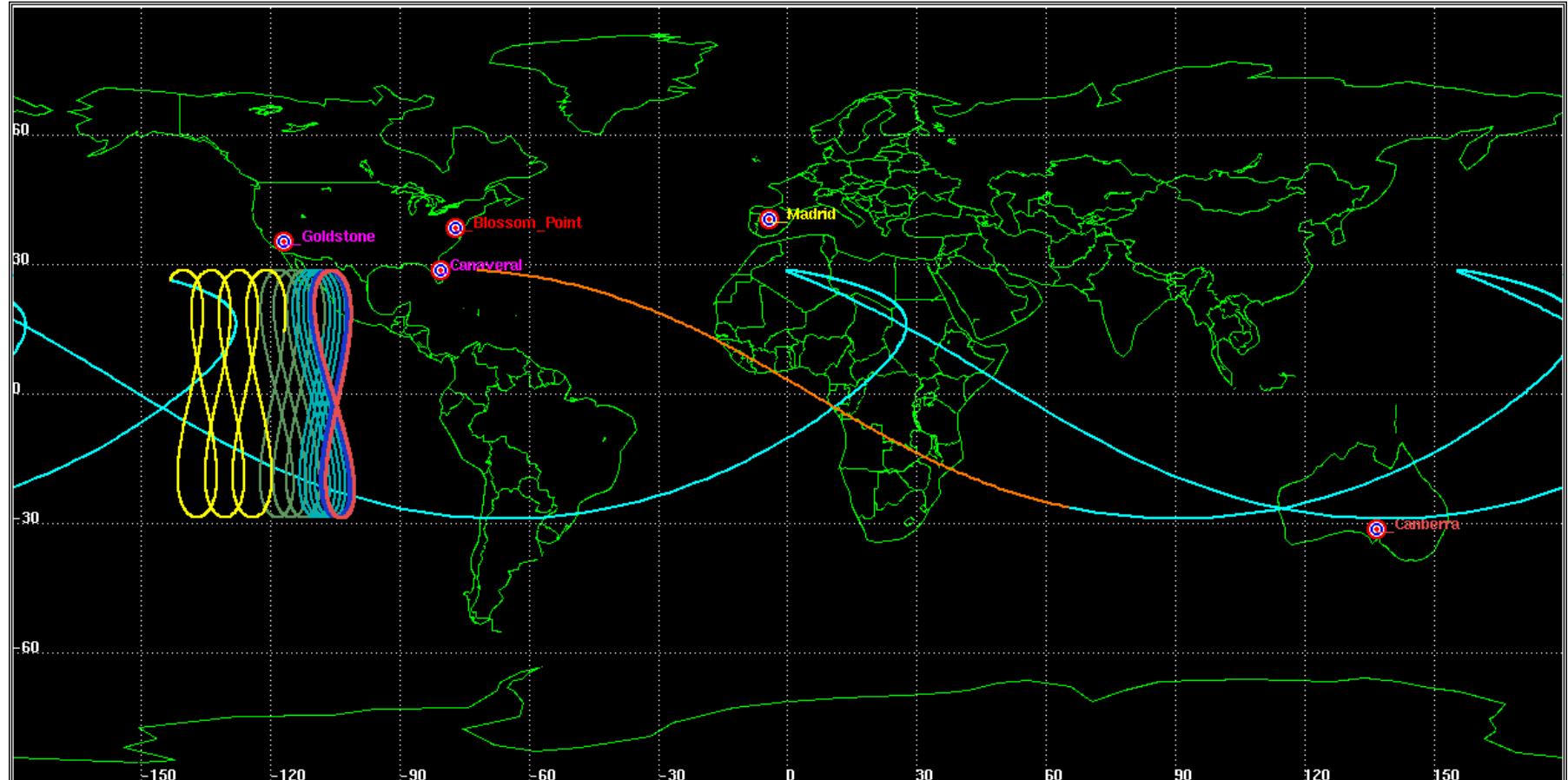
- **Drift 3.2 Revs/3.2 Days on SubSync Before Phasing Maneuvers**
- **Four Planned Phasing Maneuvers Over 12 Days Incrementally Increase Orbit Period to Match Geosynchronous Period**
  - **Raise Apogee by 525, 286, 152 and 37 km to GEO+500 km With Three, Four and Five Day Waits Between Successive Maneuvers**
  - **Final Maneuver Establishes Mission Orbit Within  $\pm 120$  Meters**
    - **Sets LAN Drift Due to Altitude Error at  $\pm 0.2^\circ$**
    - **Combined With Long-term LAN Drift and Maximum Orbit Inclination, Final Maneuver Ensures Minimum  $5^\circ$  Elevation Over BP**
- **Reserve Possibility of Mission Orbit Trim Maneuvers Ever 1.25 Years, but Not Planned**
- **After Five Years, Raise Perigee to GEO+335 km for Disposal Orbit**



# Nominal Orbit Transfer



FAME Ground Track for SubSynch Orbit Transfer



Ascent  
Parking Orbit

GTO  
SuperSynch

Phasing Orbit 1  
Phasing Orbit 2

Phasing Orbit 3  
Mission Orbit

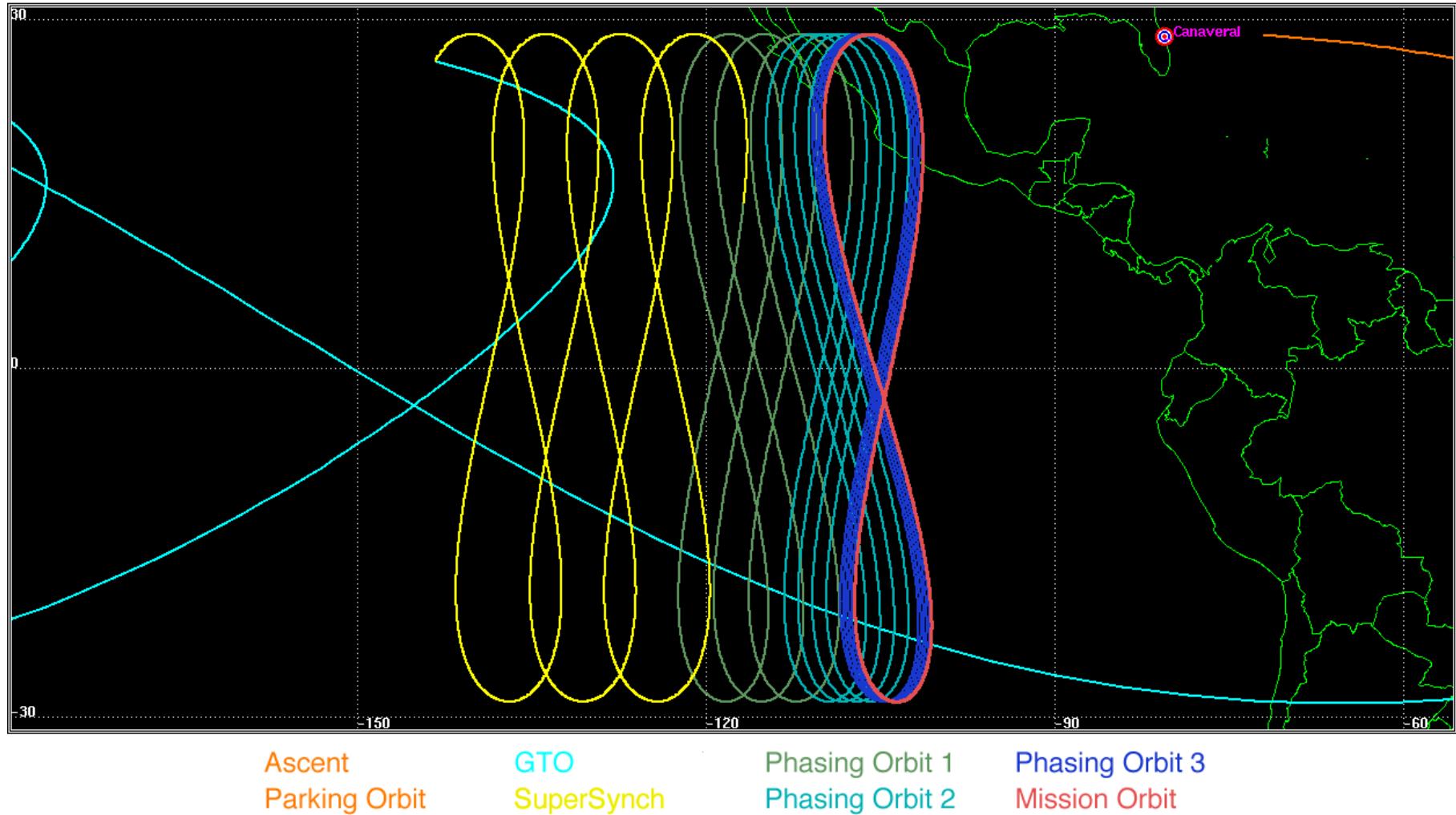
WJB 4/9/01



# Nominal Orbit Transfer (Phasing)



FAME Ground Track for SubSynch Orbit Transfer



Ascent  
Parking Orbit

GTO  
SuperSynch

Phasing Orbit 1  
Phasing Orbit 2

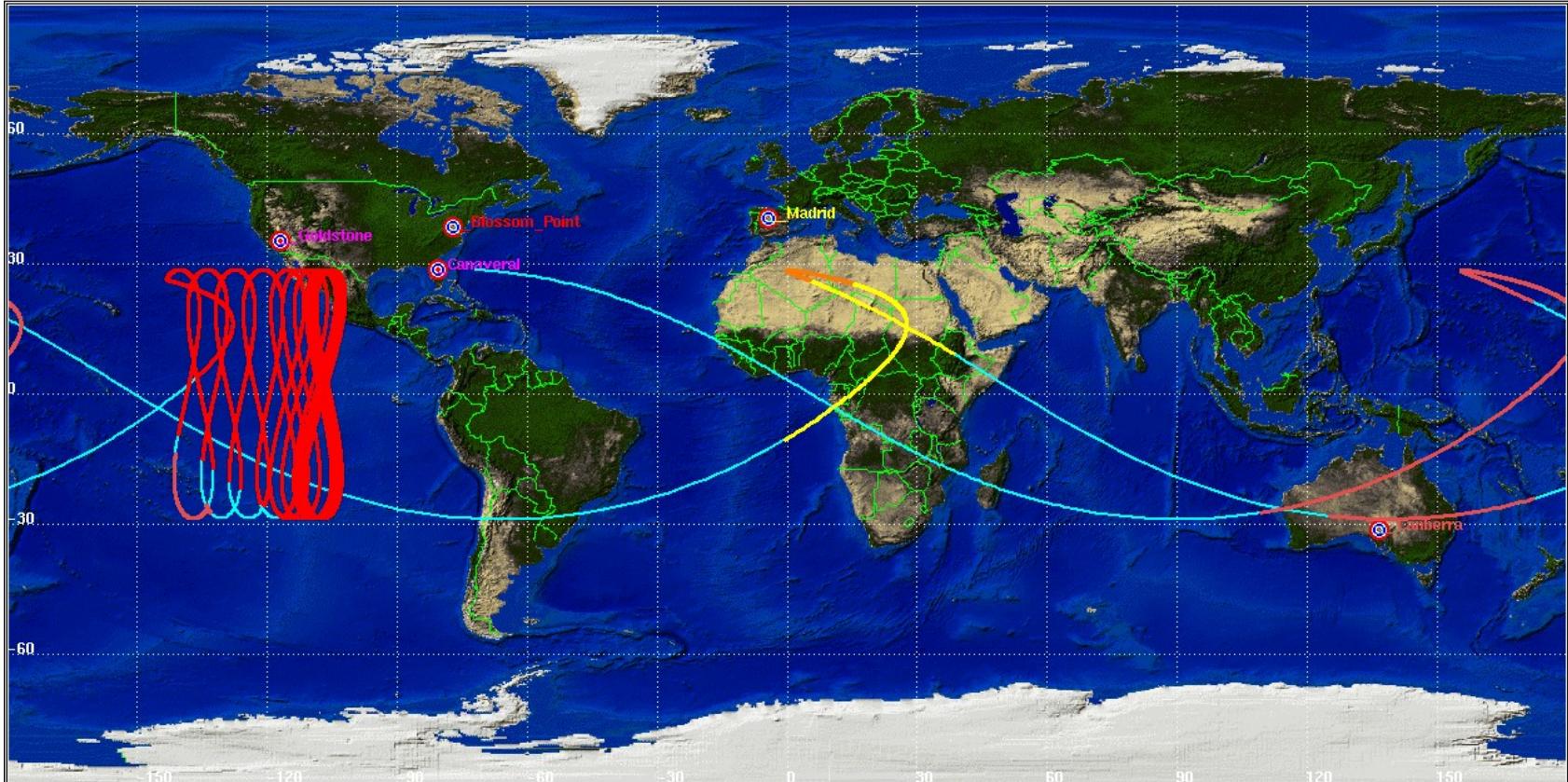
Phasing Orbit 3  
Mission Orbit



# Nominal Orbit Transfer Coverage

## FAME Coverage During Orbit Transfer

Blossom Point + DSN Stations (5° min elev)



Blossom Point Coverage

Canberra Coverage

Madrid Coverage

Joint Blossom Point/Madrid Coverage





# Orbital Debris Assessment



- **NASA Has Issued Guidelines to Comply With NASA Management Initiative (NMI) 1700.8 Which States “NASA’s Policy Is to Employ Design and Operations Practices That Limit the Generation of Orbital Debris, Consistent With Mission Requirements and Cost-Effectiveness.”**
- **Scope**
  - **Limiting Generation of Orbital Debris**
  - **Assessing the Risk of Collision With Existing Space Debris**
  - **Assessing the Potential of Spacecraft-generated Debris Fragments to Impact the Earth’s Surface**
- **Must Address**
  - **Potential for Orbital Debris Generation During Mission**
    - **Normal Operations**
    - **Malfunction Conditions (Credible Failure Scenarios)**
    - **On-orbit Collisions**
  - **Provision for Post-mission Disposal**
- **Debris Disposal Requirement Met by Placing AKM in SubSync**
- **Post-Mission Disposal Met by Placing Observatory in SuperSync at EOL**

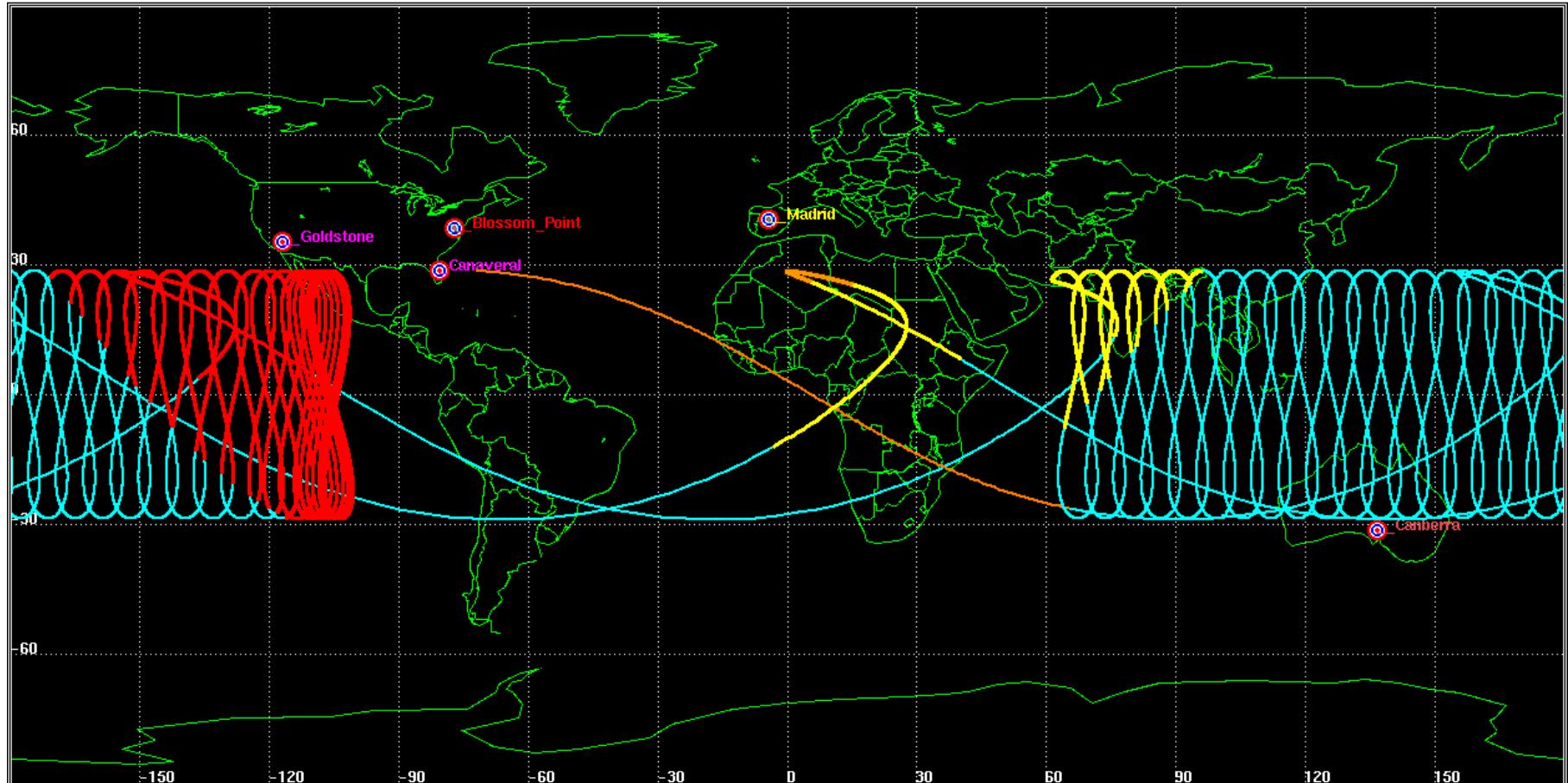


# AKMF Contingency Plan



## Coverage for Contingency AKM Firing

Blossom Point + DSN Stations (5° min elev)



Blossom Point Coverage

Madrid Coverage

Joint Blossom Point/Madrid Coverage